PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to Apparatus for Automatically Maintaining Register in Multi-Unit Rotary Web Press

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I, ARTHUR HAROLD STEVENS, a subject of the King of Great Britain, Fellow of the Chartered Institute of Patent Agents, of the Firm of Stevens, Langner, Parry & Rollinson, of 5—9, Quality Court, Chancery Lane, London, W.C.2, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to apparatus for automatically maintaining register in a multi-unit rotary web press.

In the operation of multi-colour web printing presses for intaglio printing, serious difficulty has been experienced in maintaining the register of the prints applied by the different printing cylinders. The inventors associated with my foreign correspondents have determined the cause of this difficulty and have provided, by their present invention, means for automatically maintaining register in such presses.

In an ordinary multi-color intaglio press, the printing cylinders are power driven, while the impression rollers are free so that they are rotated only by their frictional contact with the paper web. Consequently, notwithstanding the fact that the friction between the impression rollers and the web is much greater than the friction between the web and the printing cylinders, the impression rollers have no effect (apart from inertia effects during the starting and stopping of the press) on the rate of movement of the web. This rate is determined only by the peripheral speed of the printing cylinders. The failure of such presses to maintain register has been found to be due to the cumulative effect of slight differences in the peripheral speeds of the printing cylinders from slight differences in their diameters. This difficulty cannot be remedied by regulating the speeds of the printing cylinders so that they all have the same peripheral speed in spite of differences in diameters, for this would require driving the cylinders at different rotational speeds which would result in loss of register by an angular displacement of the engravings on the cylinders which would counteract the advantage of having the web fed through each unit at the same speed.

In order to avoid loss of register where the printing cylinders differ slightly in diameter, it is necessary to make the rate of travel of the web over at least one of the printing cylinders slightly different from the peripheral speed of this printing cylinder. Only a very slight difference is necessary to correct errors of register before they accumulate sufficiently to be perceptible, but it is essential that the differences be extremely slight in order to avoid perceptible blurring in the printing.

It has been proposed to drive the impression rollers by power instead of merely permitting them to ride on the web. When this is done, the impression rollers serve as the web-feeding means and determine the rate at which the web is fed through each unit, since they exercise more friction on the web than do the printing cylinders. Power driving of the impression cylinders thus provides a means for moving the web through the press at a rate which may differ from the peripheral speeds of the individual printing cylinders, and thus in theory provides a means for maintaining register notwithstanding differences in the diameters of the printing cylinders; but, when the impression rollers are power driven at a common speed of rotation, an additional difficulty appears owing to the impossibility of making the impression rollers of exactly the same diameter. Differences in the diameters of the individual impression rollers causes differences in their peripheral speeds, so that the power-driven impression rollers do not feed the web through each unit at the same speed.

In order to overcome the loss of register

in presses in which the printing cylinders may differ slightly in diameter, the present invention utilizes the impression rollers as the web-feeding means by providing a power drive for the impression rollers, and also avoids the difficulty arising from the difference in diameter of the impression rollers by providing in the drive of each individual impression roller means for making gradual, fine speed adjustments. To secure best results, the means for adjusting the speeds of the individual impression rollers should be capable of making speed adjustments which are so gradual and fine that they may properly be termed mircometric.

In accordance with the invention, in a multi-unit rotary web press, wherein all the printing cylinders are driven at the same rotational speed and the impression rollers are used as the web-moving means and are power driven so that their peripheral speeds may be different from the peripheral speeds of the printing cylinders, apparatus is provided for automatically maintaining register which is characterized by the provision in the drive of each individual impression roller of means for making gradual, fine adjustments in the speed of said impression rollers.

Furthermore, in accordance with the invention, in a multi-unit, rotary web press, wherein all the printing cylinders are driven at the same rotational speed and the impression rollers are used as the web-moving means and are each frictionally driven by a corresponding power-driven back-up roller resting thereon so that their peripheral speeds may be different from the peripheral speeds of the printing cylinder, apparatus is provided for automatically maintaining register which is characterized by the provision in the drive of each individual back-up roller of means for making gradual fine adjustments in the speed of said back-up rollers.

A controlling means actuated by differences in tension appearing in the reaches of the web between different units is utilized to set the micromatic speed-adjusting means of the individual impression rollers, and such controlling means is available to re-set the speed adjusting means in case any change in the peripheral speed of any impression roller occurs during the operation of the press.

The controlling means is so arranged that, when an inequality of tension develops between the reach of the web entering any unit and the reach of the web leaving that unit, this controlling means makes a slight adjustment in the speed of the impression roller of the unit in a sense to restore equality of tension. If this slight change of speed restores equality of tension, the controlling means becomes inactive; but, if the inequality of tension continues after this slight adjustment, the controlling means produces further slight adjustments of speed in the same sense until equality of tension is restored.

Apparatus embodying the invention may be purely mechanical in operation or may be partly electrical. Both forms are illustrated in the accompanying drawings in which Figs. 1 to 17 show a purely mechanical apparatus and Figs. 8 to 19 show an electrical form:

Fig. 1 is a side elevation of a standard roto-gravure printing press provided with mechanical apparatus embodying the invention;

Fig. 2 is a fragmentary top view of the movable rolls of one of the units;

Fig. 3 is an enlarged end view of the lower part of one of the units;

Fig. 4 is a vertical section on the line 4—4 of Fig. 3;

Fig. 5 is a horizontal section on the line 5—5 of Fig. 3;

Fig. 6 is a fragmentary vertical section on the line 6—6 of Fig. 3;

Fig. 7 is a fragmentary section on the lines 7—7 of Fig. 4;

Fig. 8 is a side elevation showing a tension-controlled electrical actuating means which may be substituted for the tension-controlled mechanical actuating means on the press shown in Fig. 1;

Fig. 9 is an enlarged fragmentary side elevation of the lower part of one of the units of the press with the gear broken away to show the gearing connecting the printing cylinder and the impression roller of the unit;

Fig. 10 is a fragmentary elevation looking lengthwise of the press and showing the gearing shown in Fig. 9;

Fig. 10a shows a modified gearing which drives the back-up roller instead of the impression roller;

Fig. 11 is a fragmentary elevation looking in the direction of the arrow 4 of Fig. 9 and showing the variable-transmission with a part of its casing broken away;

Fig. 12 shows the planetary gearing in axial section;

Fig. 13 is a fragmentary elevation of the gearing shown in Figs. 9 and 10, showing also the planetary gearing sectioned on the line 13—13 of Fig. 12;

Fig. 14 is an enlarged extension of the left-hand side of Fig. 9 showing the casing for the reducing gearing connecting the adjusting motor with the controlling worm of the variable-speed trans-

mission;

Fig. 15 is a further enlarged view of the gear casing shown in Fig. 14 with the casing broken away to show the gearing within it;

Fig. 16 is a view of the parts shown in Fig. 15 taken at right angles to Fig. 15 and showing the gear casing sectioned on the axis of the motor shaft;

Fig. 17 is a horizontal section on the line 17—17 of Fig. 15;

Fig. 18 is a fragmentary section on the line 18—18 of Fig. 17; and

Fig. 19 is a diagram of the electric connections of the apparatus.

The printing press shown in Fig. 1 has a main frame 1 on which are mounted printing cylinders 2, impression rollers 3, back-up rollers 4, an unwinding or supply roll 5a, a rewinding roll 5, feed rolls 6 for the unwinding and rewinding rolls, and guide rolls 7 for guiding a web A from the unwinding roll 5a successively between the printing cylinder and impression roller of each of the printing units of the press and then to the rewinding roll 5. The printing cylinders of all the units are driven at the same rotational speed by the usual mechanical gearing from a common drive shaft 9.

In accordance with the invention, the reaches of the web between the printing units and also the reach of the web between the unwinding roll 5a and the first printing unit and that between the last printing unit and rewinding roll 5 pass over control rolls B3, B4. Each pair of rolls B3 and B4 is mounted on a tilting frame B whose axis is a cross-shaft 14 journalled in the frame of the press. It is evident that any difference in tension between the reach of the web entering a unit and the reach of the web leaving this unit will exert a turning force on the frame B of the unit. The turning of the frame B of each unit is utilized in accordance with the invention to effect gradual adjustments in the speed of the impression roller of the unit.

In the mechanical embodiment of the invention shown in Figs. 1 to 7, a lever 15 is fixed on each tilting frame B, and the turning forces on this lever are utilized to effect gradual slight changes in the speed of the impression roller 3.

The impression roller 3 of each unit is driven from the mechanically driven shaft of the printing cylinder 2 of the unit through a differential mechanism 20 of known construction, provided with brake disks 21 and 22. The differential mechanism 20 is shown in Figs. 4, 5 and 1. A gear 20a fixed on the shaft 2' of the cylinder 2 meshes with the gear 20b floating on the shaft 3' of the impression roller 3. A cage 20 is fixed on the shaft 3'. Bevel gears 20d, 20e are rotatably mounted in the cage 20c. The bevel gear 20d is connected to the brake disk 21 (see Fig. 5) while the bevel gear 20e is connected to the brake disc 22 by a stub shaft or rod 20f which extends through a bore in the gear 20d. A radial shaft 20g is rotatably mounted in the cage 20c. A bevel gear 20h is fixed on the shaft 20g and meshes with the bevel gears 20d and 20e. A worm 20i formed on the shaft 20g meshes with a worm gear 20j on the stub shaft 20k journalled on the cage 20c. On the shaft 20k is a small gear 20l meshing with the gear 20m journalled on the cage 20c. The gear 20m meshes with the gear 20b. When both brake disks are free to rotate, the impression roller 3 is driven at such a rate that its peripheral speed is approximately the same as that of the printing roller 2. When the brake disk 21 is held against rotation, the differential mechanism 20 operates to drive the impression roller 3 at a peripheral rate slightly greater than that of the printing cylinder 2, while, when the brake disk 22 is held against rotation, the mechanism operates to drive the impression roller at a peripheral speed slightly less than that of the printing cylinder 2. Tilting forces applied to the lever 15 by differences in tension of the different reaches of the web are utilized to cause the gradual application of braking pressure to one or the other of the brake disks 21 and 22. The mechanism for accomplishing this will next be described.

Brake shoes 23 and 24 positioned to engage the brake disks 21 and 22 respectively are carried by pairs of rods 25 slidably mounted in a bar 26 secured to the front of the casing 27 of the differential mechanism 20 and spaced outwardly from the casing. Springs 28 on the rods 25 reacting against the bar 26 and adjustable nuts 29 on the outer ends of the rods tend to urge the brake shoes 23, 24 outwardly away from the brake disks 21, 22. Inward movements of the brake shoes are effected by toggles 30, 31 operated by a shaft 32 journalled on the bar 26 and connected with the lever 15 by a crank 33 and a connecting rod 34, so that tilting movements of the lever 15 cause turning movements of the shaft 32. A weight 34' is provided to counterbalance the weight of the connecting rod 34.

Each of the toggles consists of a threaded stud 35 screwed in a transverse bore in the shaft 32 and a rod 36 extending from the inner end of the stud to the brake shoe. The inner ends of the studs 35 and the outer surfaces of the

brake shoes 23, 24 contain spherically curved recesses which hold the spherically curved, convex ends of the rods 36. When the lever 15 is horizontal, the toggles 30, 31 are bent in opposite directions, as shown in Fig. 4. A tipping of the lever 15 in either direction, causing a turning of the shaft 32, straightens one or the other of the toggles and thus forces one or the other of the brake shoes against the corresponding brake disk. In straightening, each toggle gradually applies a braking force which becomes a maximum when the toggle is straight and is then sufficient to lock the disk against any movement. Turning of the shaft 32 in either direction is limited to that necessary to straighten one or the other of the toggles by the engagement of a block 37 fixed on the shaft with the bar 26 (Figs. 3 and 6). The braking force applied by each toggle may be regulated by screwing its stud in or out in the shaft 32 and by adjusting the nuts 29 to vary the tension of the springs 28.

It will be seen that the mechanism connecting the lever 15 of each unit with the brake shoes 23, 24, of that unit, which has been described, provides a simple and direct mechanical means for utilizing the difference in the tensions of the reach of the web entering the unit and that leaving the unit to apply gradually a braking pressure to one or the other of the brake disks of the differential mechanism through which the impression roller of the unit is driven.

The operation of the apparatus described is as follows:

The web is initially led through the machine as shown in Fig. 1 in such manner that the tension on the different reaches of the web is uniform, so that each of the swinging frames B and levers 15 is in horizontal position. This places the toggles of each unit in the bent position shown in Fig. 4, allowing the springs 28 to draw the brake shoes free from the brake disks. Each impression roller 3 is then driven at a rotational speed directly proportional to that of the printing cylinder of the unit, so that the rates of speed of the web through the different units are proportional to the peripheral speeds of the impression rollers which exercise a greater friction on the web than the printing cylinders. Since it is impossible to make the impression rollers of absolutely uniform diameter, the peripheral speeds of the impression rollers will vary slightly when all the impression rollers are thus driven at the same rotational speed. For the sake of illustration, it will be assumed that the diameter of the impression roller of the middle unit is slightly larger than the other impression rollers, so that, when the levers are all in neutral position, the web travels through this unit a little more rapidly than through the other units. This will result in increasing the tension on the reach of the web between the first and second units and decreasing the tension on the reach of the web between the second and third units. As soon as this difference in tension starts to develop, the web will apply a turning force to the frame B and lever 15 in a clockwise direction (Fig. 1). This turning force is applied through the connecting rod 34 and the crank 33 to cause a turning force on the shaft 32 in an anticlockwise direction (Fig. 4). This force gradually overcomes the pressure of the springs 28, straightening the toggle 31 and pressing the brake shoe 24 against the brake disk 22. The retarding of this brake disk operates the differential mechanism 20 to decrease the speed of the impression roller. The decrease in speed of the impression roller results in the decrease of the rate of travel of the web through the middle unit. This rate of travel continues to decrease until the tensions of the web on the opposite sides of the middle unit again become equal, relieving the frame B and lever 15 of any turning force from the web and allowing the springs 28 to draw the toggle 31 into bent position to release the brake shoe from the brake disk so that the impression roller 3 is again driven at its original speed.

If the diameter of the impression roller of the second unit happens to be less than that of the impression rollers of the other units, a similar but opposite adjustment will be caused by the turning force on the frame B and lever 15 in the direction opposite from that in the illustration just described, so that it straightens the toggle 30 and applies the brake shoe 23 to the brake disk 21 to increase the speed of rotation of the impression roller.

The maximum changes in the speed of rotation of the impression roller which can occur in the automatic adjustments described is limited by the design of the differential mechanism to a very small increment or decrement of the normal speed of the roller. Such maximum changes of speed occur only when one or the other of the brake shoes is pressed inward with a force sufficient to stop the rotation of one of the brake disks. During the gradual application of the braking force, the brake disk is at first merely retarded. Such retarding causes a change in the speed of rotation of the impression roller less than the maximum

change which would be caused by stopping rotation of the brake disk. If this slight change in the speed of the impression roller is not sufficient to restore equality of tension, the inequality of tension increases, causing additional braking effect on the disk and a further change in the speed of rotation of the impression roller. The small changes of speed continue to be made until the speed of the impression roller is changed sufficiently to restore equality of tension. The automatic adjustment is thus very delicate and certain.

Where, as is usually the case, there are slight differences in diameter between all the impression rollers, automatic adjustments such as have been described will occur in all the units whenever any variations in the tensions of the reaches of the web develop and in this way register will be repeatedly restored and the average rates of travel of the web through each of the units will be maintained exactly the same no matter how long the press may operate.

In the electrically controlled apparatus embodying the invention illustrated in Figs. 8 to 19, the tilting frame B of each unit carries an arm B5 which depends between two normally open electric switches B6, B7. An operating head B8 at the lower end of the arm B5 is positioned to operate the control arm B10 of the switch B6 to close the switch B6 and to close the switch B7 through its operating arm B9. A manual lock B11 may be provided to prevent swinging of the arm B5 while a web is being threaded through the press. When the arm B5 is unlocked, the arm will respond to differences in tension between the reach of the web A entering one of the units and the reach of the web leaving this unit, so that, when the tension on the entering reach is greater than on the leaving reach, the switch B7 will be closed, and when the tension is the greater on the leaving reach, the switch B6 will be closed, and when the two tensions are equal both switches will remain open.

Electric circuits controlled by the switches B6, B7 of the control of each unit are used to cause gradual micrometric adjustments of the rate of travel of the web through the unit. This rate of travel depends upon the peripheral speed of the impression roller of the unit. The impression roller of each unit is mechanically driven through a planetary gearing C, Fig. 12, whose effective gear ratio is determined by a variable-speed transmission D, Fig. 11, whose gear ratio is adjusted by a reversible electric motor M, Fig. 16, connected in an electric circuit controlled by the switches B6, B7 in such manner that the motor is driven in one direction when the switch B6 is closed and in the other direction when the switch 7 is closed, and the motor is stationary when both are open.

The impression roller 3, Fig. 10, of each unit is driven from the printing cylinder 2 of the unit through the planetary gearing C. The shaft of the printing cylinder 2 drives the input gear C1, Figs. 9, 10, 12 and 13, of the planetary gearing C through gears F1 and F2. The output gear C2 of the planetary gearing C drives the impression roller 3 through a chain of gearing including pinion F3 and bevel gear F4 both fixed on a horizontal stud shaft F5, bevel gears F6 and F7 on a vertical shaft F8, bevel gear F9 and pinion F10 fixed on a horizontal stub shaft F11, gear F12 rotatably mounted on the end part 12 of the back-up roller 4, and gear F13 fixed on the shaft of the impression roller. In order that the gearing may not interfere with raising the slide 10 in which the shafts of the rollers 3 and 4 are mounted, the horizontal stub shaft F11 and a bearing for the bevel F7 are mounted on a bracket F14 which is mounted on the slide 10, and the gear F7 is splined on the vertical shaft F8 which is journalled in a bracket F15 secured to the side frame 11 of the press.

The planetary gearing C is best shown in Figs. 12 and 13. The input gear C1 is keyed to a central shaft C3. Also keyed to the shaft C3 is a sun gear C4 meshing with a planetary gear C5 fixed on a stud shaft C6 mounted on a cage C7 rotatable about the shaft C3. Another planetary gear C8 is fixed on the stub shaft C6 and meshes with a sun gear C9 fixed on a sleeve C10 rotatably mounted on the shaft C3. This sleeve C10 carries the output gear C2 of the planetary gearing. The two sun gears C4 and C9 differ slightly in pitch diameter and number of teeth, as do also the two planetary gears C5, C8.

The effective gear ratio of the planetary gearing, that is, the relative rate of rotation of the input gear C1 and the output gear C2 depends, as is well understood, on the relative rate of rotation of the sun gear C4 and the cage C7. This relative rate of rotation is determined by the variable-speed transmission device D whose input shaft D3 carries a gear D4 meshing with and driven by the input gear C1 of the planetary gearing C, and whose output shaft D1 drives the cage C7 through a gear D2 fixed on the shaft and a gear C11 fixed on the cage.

The variable-speed transmission D pro-

vides for a gradual change of speed over a wide range. In the form shown in Fig. 11, the input and output shafts, D1 and D3. of the device are connected by a link belt D5 passing over pulleys D6, D7, whose effective diameters may be varied in opposite senses by turning levers D8 by means of a right and left hand screw D10. The variable-speed transmission D may be of any suitable known construction, for example, of that shown in British Patent No. 441,889, and is, therefore, not described in detail herein.

The controlling screw D10 of the transmission D is turned by the adjusting motor M whose operation is controlled by the switches B6 and B7 in the manner heretofore noted. The motor M is connected to the controlling screw D10 through reducing gearing best shown in Figs. 14, 15, 16 and 17. A pinion M1 on the motor shaft meshes with a large idler gear M2 on which is fixed a pinion M3 which meshes with a gear M4 splined to a shaft M5. A sprocket M6 is secured on the shaft M5 by a safety clutch M7 and this sprocket is connected by a chain M8 with a larger sprocket M9 fixed on the screw D10. Thus rotation of the motor in either direction turns the screw D10 at a rate of rotation very much less than that of the motor shaft.

To secure very accurate speed adjustment, damping means are provided to check turning of the screw as the result of the momentum of the motor armature and the associated gearing after current to the motor is cut off. The damping means include a friction disk M10 loosely mounted on the shaft M5 and sandwiched between the gear M4 and a disk M11 splined on the shaft M5 and pressed against the friction disk by a spring M12. The friction disk M10 has two radial arms M13 and M14. The arm M14 projects between two adjustable stops M15, M16 which limit the turning movements of the friction disk M10 by engagement with the arm M14 (Fig. 15). The arm M13 is secured to a plunger M17 provided with balanced compression springs M18, M19 which tend to restore the friction disk M10 to its normal position shown in Fig. 15 in which its arm M14 is midway between the stops M15 and M16.

The arm M14 of the friction disk M10 is connected to a normally closed electric switch M20 controlling the circuit of the motor M in such manner as to open this switch when the arm is moved in either direction through a distance somewhat less than that necessary to bring the arm into contact with one of the stops M15 or M16. The connection between the arm M14 and the switch M20 is best shown in Figs. 17 and 18. It includes a stud shaft M21 having at one end a fork M22 engaging a stud M23 on the arm M14 and at the other end a cam M24 with adjustable sectors M25 positioned to engage and move the operating lever M26 of the switch M20 whenever the shaft M21 is turned a short distance in either direction by the engagement of the fork M22 with the stud on the arm M14.

The operation of the mechanism connecting the adjusting motor with the screw D10 is to cause a turning of the screw by small, accurately predetermined steps. This is because the springs M12, M18 and M19 are so adjusted that the friction disk M10 turns with the shaft M5 when the shaft is turned, but is restored to its normal position shown in Fig. 15 by one of the springs M18, M19 when turning movement of the shaft M5 ceases. Consequently, when current is supplied to the adjusting motor M by the closing of one or the other of the switches B6, B7 and the motor starts to turn the shaft M5 and the worm D10 through the gearing which has been described, the friction disk M10 turns with the shaft until its arm M14 strikes one of the stops M15 or M16. Before the completion of this short turning movement, the arm M14 of the disk has acted through the parts mounted on the shaft M21 to open the switch M20 and cut off current to the motor. Notwithstanding the cutting off of the current, the inertia of the parts carries the disk M10 on until its arm M14 strikes one of the stops. The friction disk M10 is then held stationary and by the friction between it and the gear M4 quickly brings the shaft M5, and, of course, also the motor shaft and the screw D10, to a complete stop. One or the other of the springs M18, M19 then returns the friction disk to its normal position, allowing the switch M20 to close and re-energizing the motor if one of the switches B6 or B7 is still closed. The operation is then repeated producing another small turning step of the screw D10.

The electric circuit of the adjusting motor M is so arranged that the motor is idle when the normally closed switch M20 is open, and is turned in one direction when the switch M20 is closed and the switch B6 is closed, and is turned in the other direction when the switch M20 and the switch B7 are closed. The exact arrangement of the circuit will, of course, depend on the type of current available. A convenient circuit for a press driven from a three-phase line is shown in Fig. 19. This figure shows a three-phase line E1 to which the main motor of the press

E2 is connected. This is the motor which drives the printing cylinders 2 through the drive shaft 9. The adjusting motor M is connected to the line E1 through a normally open reversing switch E3. A relay circuit E4 extends between two of the wires of the line E1. This circuit contains the normally closed switch M20 and has two parallel branches of which one, E5, contains the normally open switch B7 and a coil E6 for closing one-half of the reversing switch E3, and the other branch E7 contains the normally open switch B6 and a coil E8 for closing the other half of the reversing switch E3.

The operation of the apparatus described may most easily be explained by assuming that, when the press is started, the variable-speed transmission D of each unit is set with the ratio of the diameters of its two pulleys D6, D7 equal to the ratio of the diameter of the gears D2 and D4 on its input and output shafts, so that the cage C7 of each unit is planetary gearing C of each unit is driven at the same speed as the main shaft C3 of the gearing, making the gear ratio of the planetary gearing equal to unity. Under these conditions, the impression rollers 3 of all the units are driven at the same speed of rotation, so that the web A would travel through all the units at the same rate if the diameters of all the impression rollers 3 were exactly the same. Exact equality between the diameters of the impression rollers cannot be obtained in practice, and in consequence differences in tension appear in the different reaches of the web.

To continue the explanation of the operation of the device, it will be assumed that the diameter of the impression roller 3 of one of the units is less than the diameters of the impression rollers of the units at each side of it. While the rotational speed of the impression rollers of the three units is equal, the web A will travel more slowly through the unit having the smaller impression roller than through the units at each side of it, so that the tension of the reach of the web leaving this unit will be increased, while the reach of the web entering this unit will slacken. The difference in tension between the entering and leaving reaches will cause the arm B5 to close the switch B6, starting the adjusting motor M in such direction as to change the pulley diameters of the transmission D to increase the speed of rotation of its output shaft D3, and thus to increase the speed ratio of the planetary gearing C slightly above unity. This slight increase will take place by minute steps because of the operation of the connection between the adjusting motor M and the controlling screw D10 of the transmission D, as has already been explained. The gradual increase in speed by small increments will continue until the impression roller 3 of the unit in question rotates fast enough to take up the slack on the entering reach of the web and to lessen the tension on the leaving reach, and thus restore the tensions of the reaches at opposite sides of the unit to equality. As soon as this happens, the switch B6 will open and stop the motor M, which stops the increase of the gear ratio of the planetary gearing C and the increase of speed of rotation of the impression roller 3. The impression roller will then continue to be driven at the speed at which it was driven when equality of tension was restored. This speed, it will be noted, is greater than the initial speed of the impression roller at which it was driven before the closing of the switch B6.

The web will now be travelling through the unit in question a little faster than it is traveling through the adjacent units, so that after a time a difference in tension between the entering and leaving reaches will develop which this time will operate to close the switch B7, to operate the motor M in a direction to decrease the speed of the output shaft of the variable-speed transmission D, and so gradually to decrease the gear ratio of the planetary gearing C. When the decrease of speed of the impression roller is stopped by restoration of equality of tension in the entering and leaving reaches, the speed of the impression roller will be slightly less than it was after the first adjustment and more nearly equal to the speed required to move the web through the unit in question at the same rate as that at which it is moving through the adjacent units. After a few operations of the mechanism in the manner described occurring at increasing intervals of time, the speed of the impression roller of the unit in question will be made, for all practical purposes, equal to that necessary to move the web through this unit as fast as it is moving through the adjacent units. The frame B and the motor M will then remain stationary.

The actual operation is slightly complicated by the fact that there will be differences in diameter between the impression rollers of all the different units, but the effect will be that, after a few automatic speed adjustments in each unit, the impression-roller driving mechanism of the various units will be set at the speeds required to move the web through

each unit at the same speed and register will thus be continuously maintained without further adjustments. This desirable operation is the result of the fact that, on each restoration of equality of tension at the two sides of any unit, the speed of the impression roller is maintained at the speed to which it has been adjusted, and the fact that the speed adjustments are extremely gradual and accurate since wide changes in the speed ratio of the variable-speed transmission D cause only very slight changes in the gear ratio of the planetary gearing C.

While the speed-adjusting mechanism described performs its function near the beginning of a printing run so that it may not be required to operate at any appreciable extent thereafter, it is nevertheless always in readiness to operate in case equality of tension at the two sides of any unit is disturbed during the run, as may occur as the result of a slight change in the diameter of one of the impression rollers through a change in temperature or through wear.

A modification of the apparatus shown in Fig. 10a makes the speed of travel of the web through the various units independent of the diameters of the impression rollers 3. This modification consists in fixing the gear F12 on the back-up roller 4 and omitting the gear F13 on the impression roller shaft. In this modification the impression roller is driven by frictional contact with the back-up roller so that the peripheral speed of the impression roller is equal to the peripheral speed of the back-up roller. In this case, the differences in tension in different reaches of the web which arise before the adjusting mechanism operates are caused by minute differences in diameter between the back-up rollers 4 of the various units instead of by differences in diameter in the various impression rollers. As the back-up rollers are metal, it is possible to make and maintain their diameters more uniform than the diameters of the impression rollers which are rubber. The use and modification shown in Fig. 10a, therefore, requires somewhat less operation of the adjusting mechanism to secure continued uniformity in tension than the arrangement first described; but, on the other hand, it does not control the speed of the web through the different units as positively as the form first described in which the adjusting mechanism is geared directly to the impression rollers.

From the above description, it will be seen that the mechanical apparatus illustrated in Figs. 1 to 7 and the electro-mechanical apparatus illustrated in Figs. 8 to 19 operate in substantially the same way in keeping the tension on the web uniform and securing perfect registration; and that the electro-mechanical apparatus has the additional advantage of retaining the adjusted speed of the web-moving means when equality of tension has been restored, instead of returning the speed of the web-moving means to its original value, and, therefore, after a comparatively short period of "hunting", sets the speed of the web-moving means of each unit at that necessary to maintain equality of tension and thus avoids the continual making of speed adjustments which occurs in the operation of the mechanical apparatus of Figs. 1 to 7.

It will be understood that various modifications may be made in the arrangements described without departing from the scope of the invention.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed (as communicated to me by my foreign correspondents), I declare that what I claim is:—

1. In a multi-unit, rotary web press, wherein all the printing cylinders are driven at the same rotational speed and the impression rollers are used as the web-moving means and are power driven so that their peripheral speeds may be different from the peripheral speeds of the printing cylinders, apparatus for automatically maintaining register which is characterized by the provision in the drive of each individual impression roller of means for making gradual, fine adjustments in the speed of said impression rollers.

2. In a multi-unit, rotary web press, wherein all the printing cylinders are driven at the same rotational speed and the impression rollers are used as the web-moving means and are each frictionally driven by a corresponding power-driven back-up roller resting thereon so that their peripheral speeds may be different from the peripheral speeds of the printing cylinder, apparatus for automatically maintaining register which is characterized by the provision in the drive of each individual back-up roller of means for making gradual fine adjustments in the speed of said back-up roller and thereby in the speed of the corresponding impression rollers.

3. Apparatus as claimed in claim 1 or 2, in which said speed-adjusting means are automatically controlled by the tension of the reaches of the web between the units.

4. Apparatus as claimed in claim 3, in

which controlling means operated by difference in tension of the reaches of the web at opposite sides of a unit gradually changes the peripheral speed of the impression roller of the unit until equality of tension is restored.

5. Apparatus as claimed in claim 4 in which the controlling means is automatically actuated by a difference in tension between the reaches of the web at opposite sides of a unit to cause a slight change in the speed of the impression roller of the unit in a sense tending to restore equality of tension and is then actuated to cause a further change of speed in the same sense if equality of tension has not been restored by the first change in speed.

6. Apparatus as claimed in any one of claims 1 to 4 in which the operation of the controlling means is purely mechanical and serves to apply a force created by the differences in the tensions of the reaches of the web at opposite sides of a unit to braking means which adjusts the speed of the impression roller.

7. Apparatus as claimed in claim 6 in which the braking means for adjusting the speed of the impression roller operates on a differential mechanism through which the impression roller is driven.

8. Apparatus as claimed in claim 7 in which the differential mechanism through which the impression roller is driven has two brakes and is arranged to cause an increase in the speed of the impression roller when one of said brakes is applied and a decrease in the speed of the impression roller when the other of said brakes is applied, and the controlling means is arranged to apply a gradually increasing braking force to one of said brakes when the tension of the web entering the printing unit is greater than the tension of the web leaving the printing unit and to the other of said brakes when the tension of the reach of the web leaving the unit is greater than the tension of the web entering the unit.

9. Apparatus as claimed in claim 8 in which the controlling means operates on the brakes through the toggle arrangement shown in Figs. 3, 4 and 5.

10. Apparatus as claimed in any of claims 1 to 5 in which the automatic controlling means is arranged to maintain the adjusted speed after each operation thereof.

11. Apparatus as claimed in claim 10 in which the controlling means is operated by differences in tension in the reaches of the web at opposite sides of a unit to gradually change the peripheral speed of the impression roller of the unit until equality of tension is restored and is operated by the restoration of equality of tension to maintain the speed of the impression roller at the value which it had on the restoration of equality of tension for so long as such equality continues.

12. Apparatus as claimed in any one of claims 1 to 5, in which the means for making gradual fine speed adjustments includes two variable-speed transmissions, one variable-speed transmission being connected between the driving means and the other variable-speed transmission in such manner that a wide variation in the first transmission causes a slight variation in the second transmission.

13. Apparatus as claimed in claim 12 in which the second transmission is a planetary gearing containing input and output sun gears of slightly different pitch diameters and two planetary gears mounted on a cage member for rotational movement about said sun gears so that the effective gear ratio of the planetary gearing is a small fraction of the ratio between the rate of rotation of the input sun gear and the rate of rotation of the cage member, and the first variable-speed transmission is connected between the input sun gear and the cage member.

14. Apparatus as claimed in any of claims 6 to 13 in which the controlling means operates a reversible electric motor, and said motor causes movement of a speed-controlling member in a series of minute steps.

15. Apparatus as claimed in claim 14 in which the reversible motor is connected to the speed-controlling member by gearing, and a damping member in frictional contact with a rotary element of said gearing is arranged to cut off the supply of electricity to the motor on a short turning movement of said element and to damp the rotation of the motor after such cut-off.

16. Apparatus for automatically maintaining register in a multi-unit, rotary, web press, substantially as hereinbefore described and illustrated in the accompanying drawings.

Dated this 3rd day of February, 1941.

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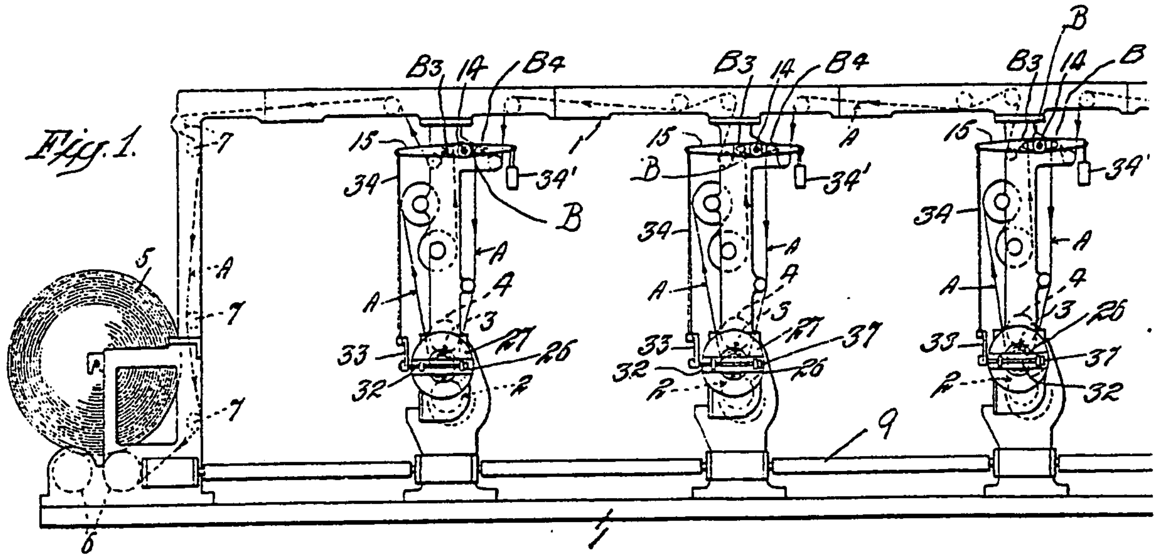
New York, U.S.A.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1943.

Fig. 1.



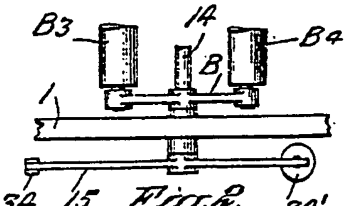


Fig. 2.

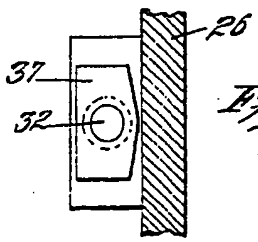
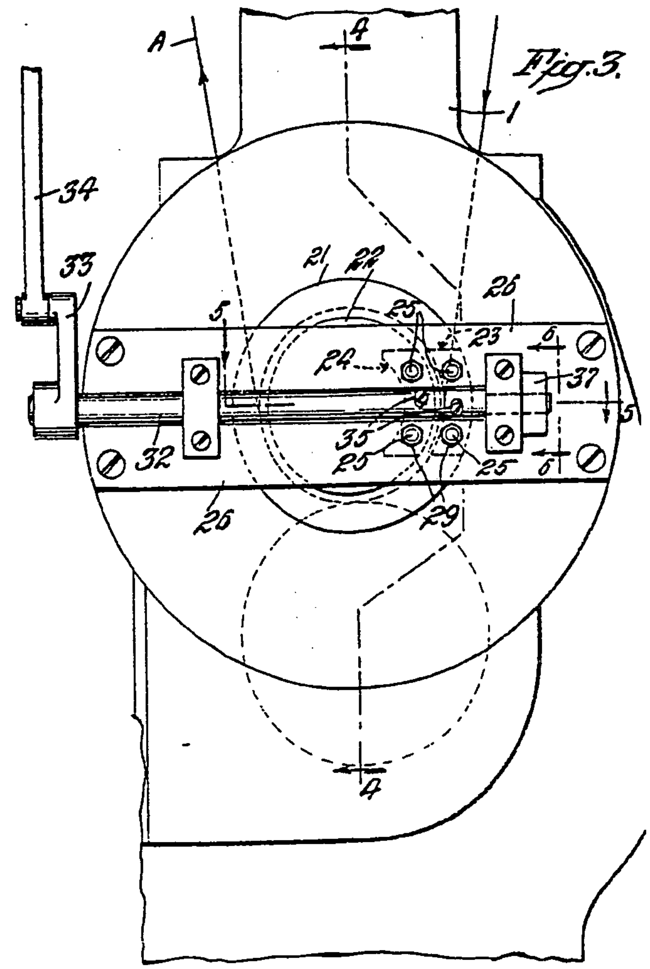
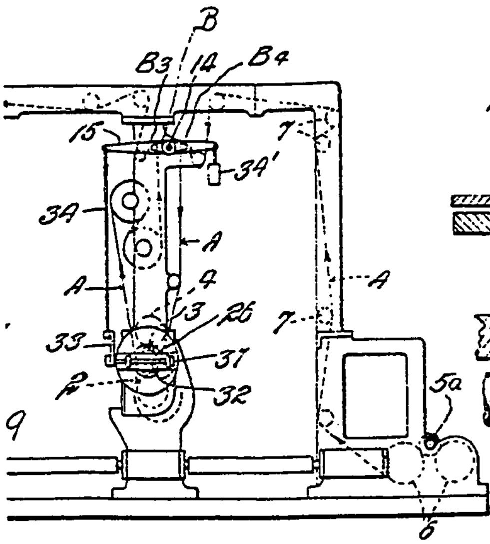


Fig. 6.

Fig. 3.





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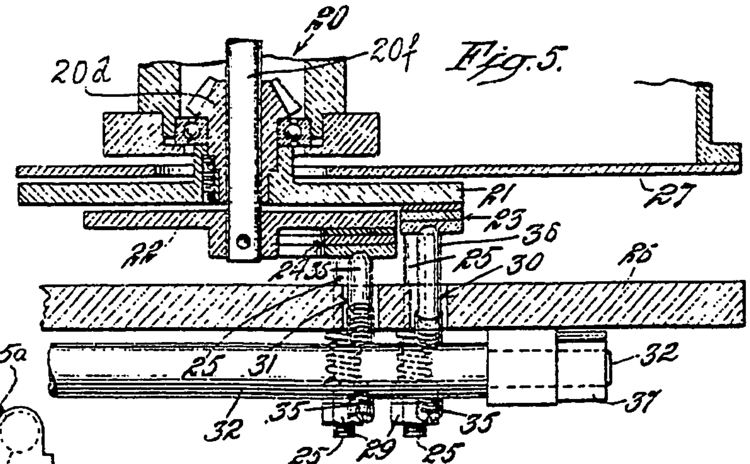
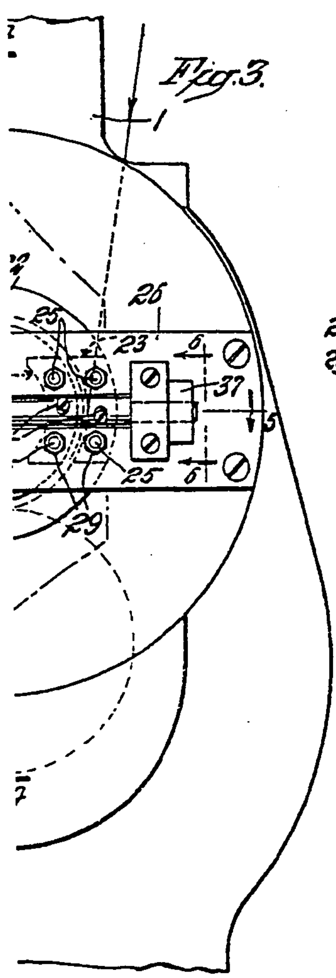


Fig. 3.



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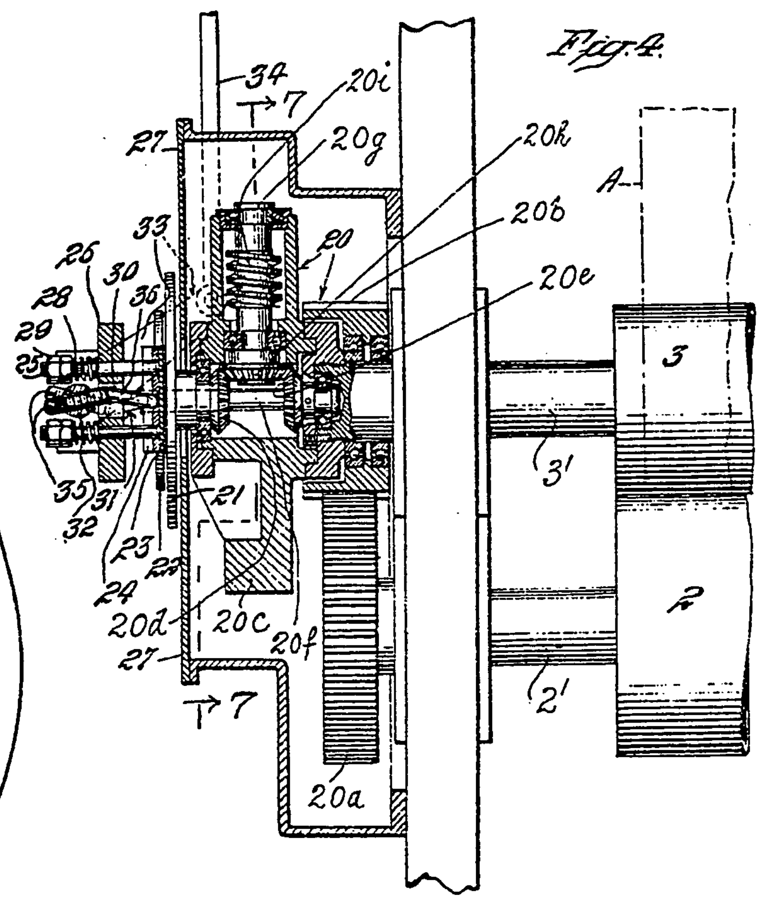

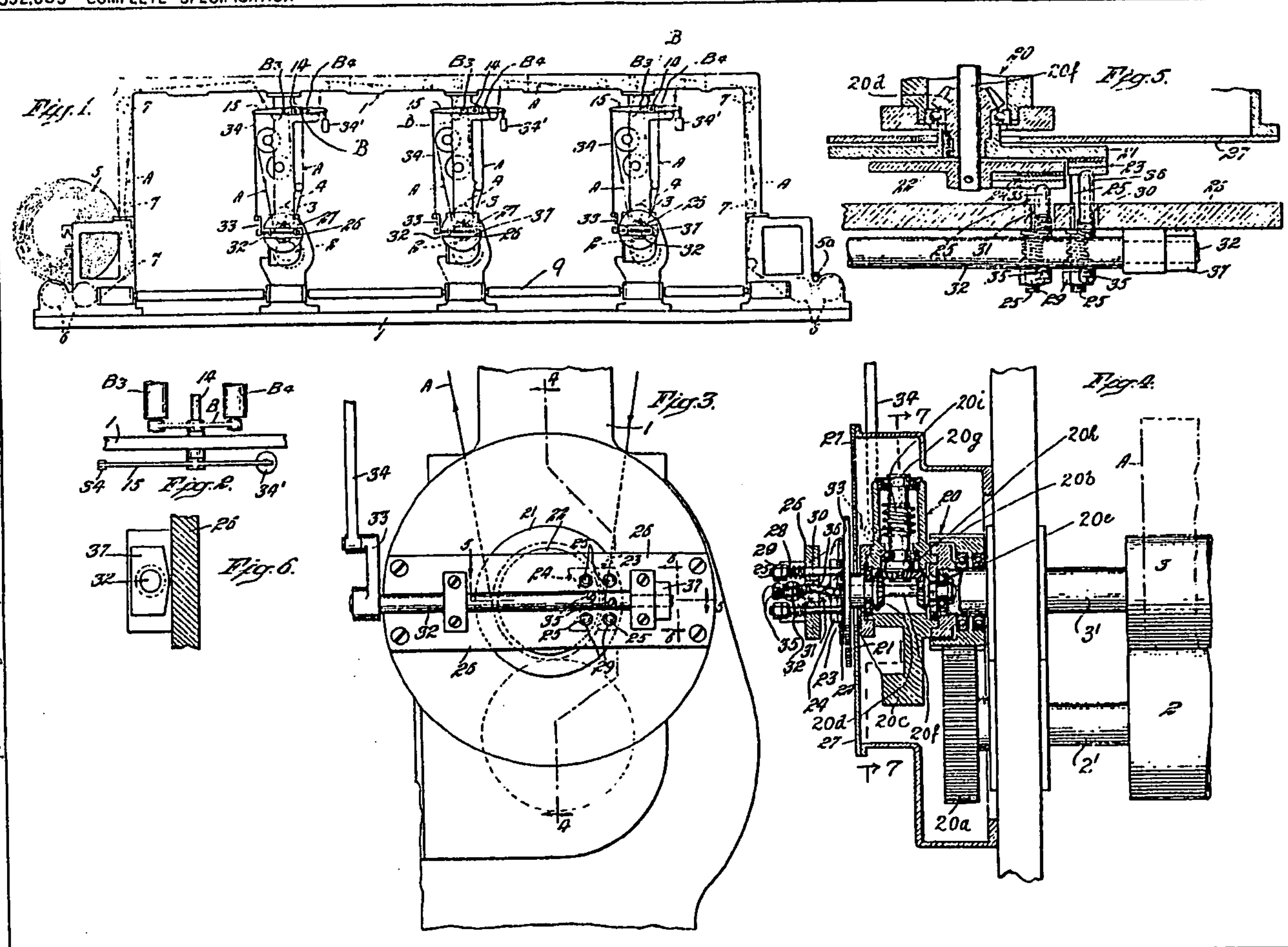

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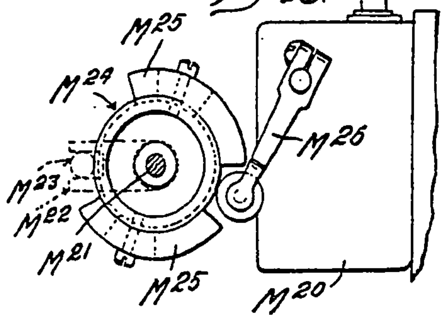
Fig. 18.



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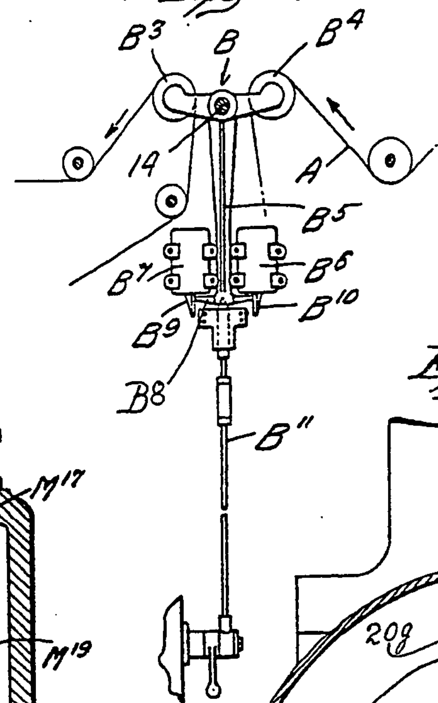

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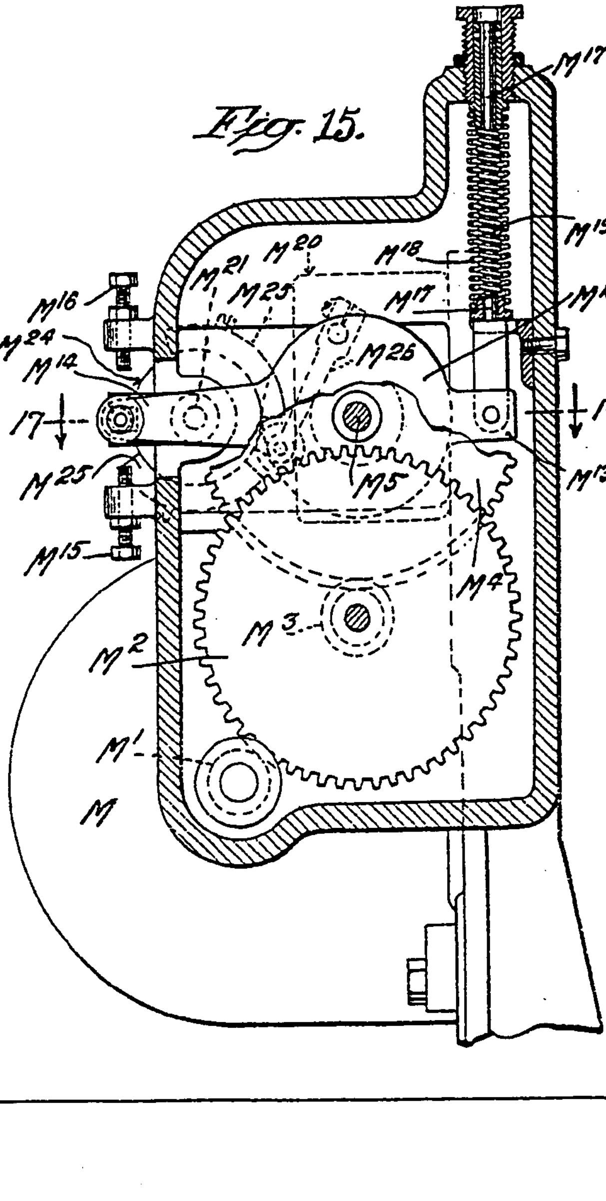

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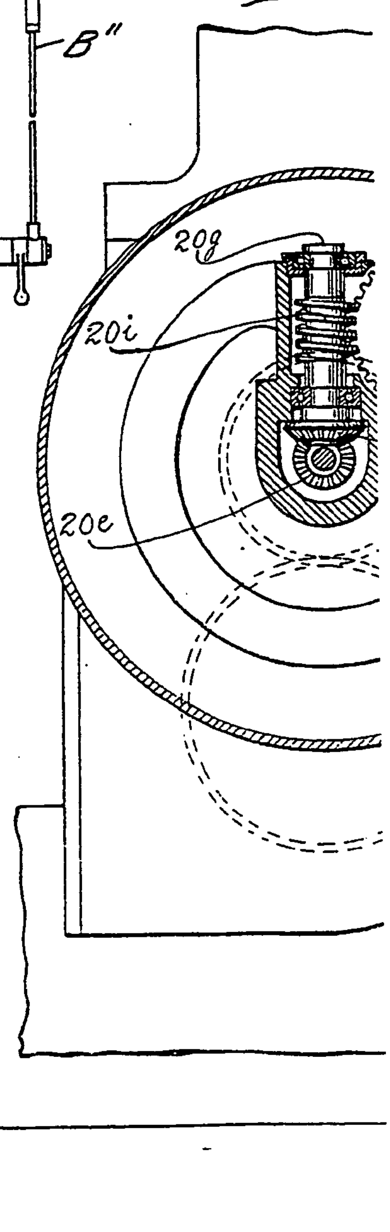

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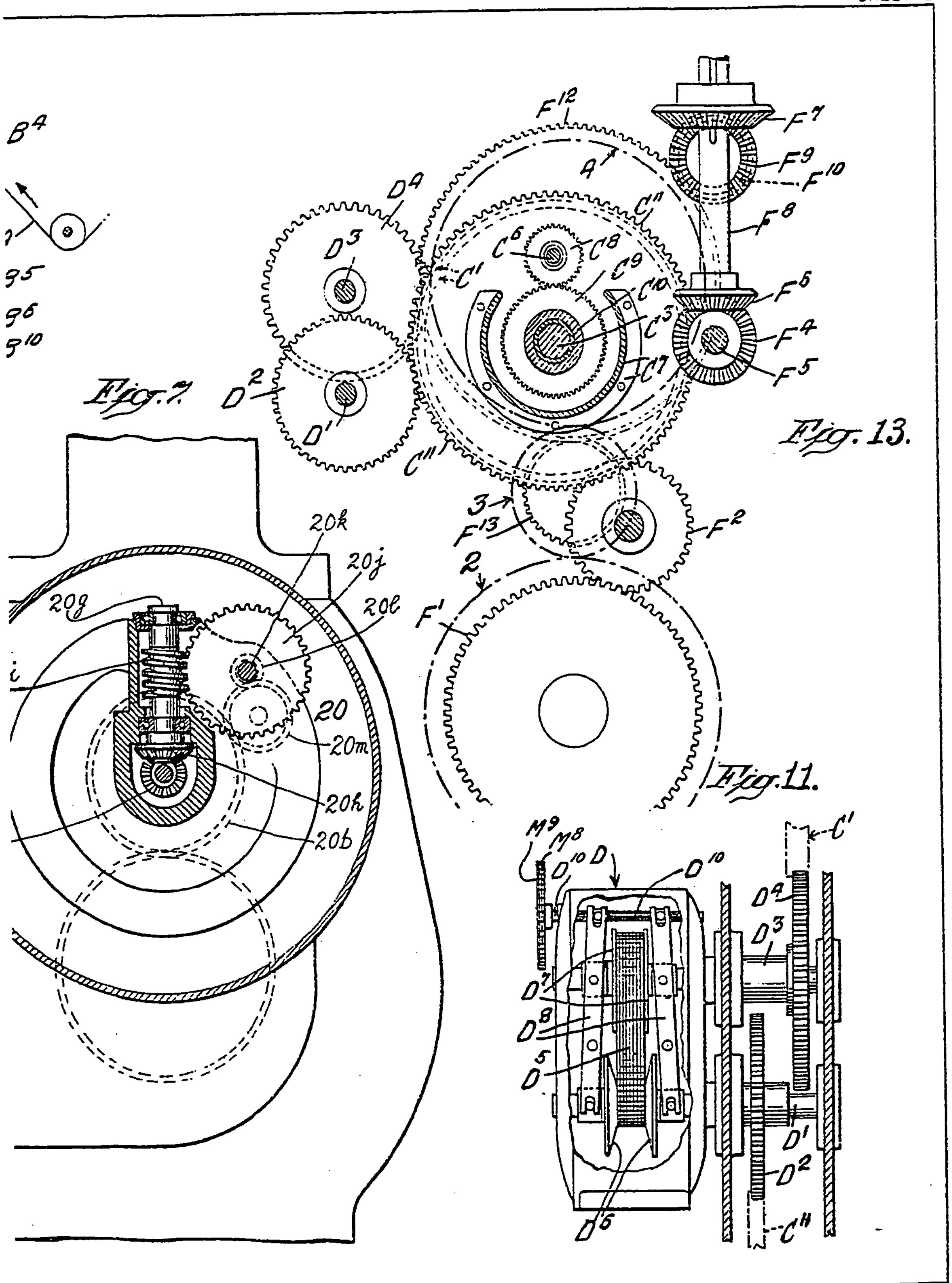
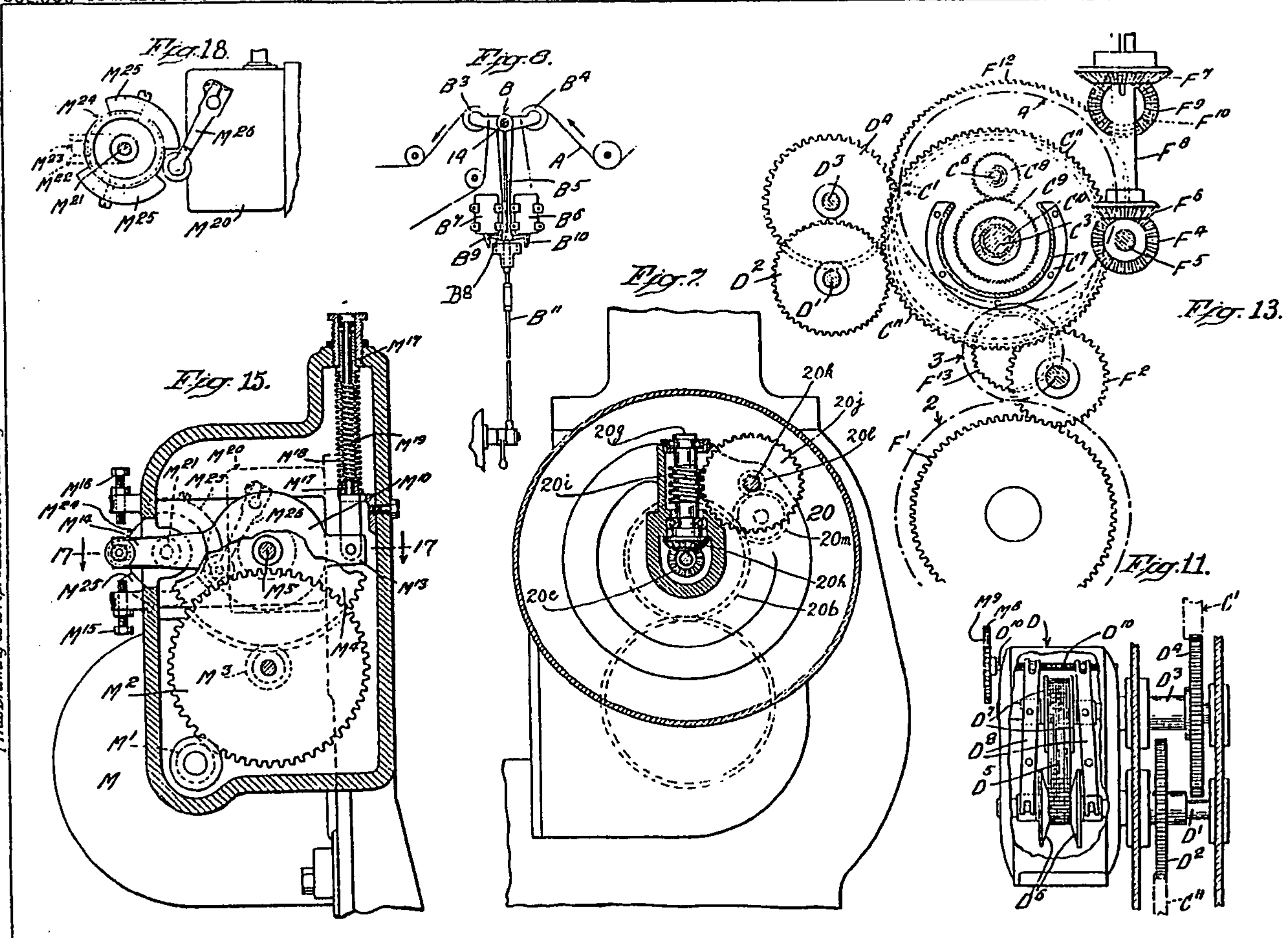


Fig. 7.

Fig. 13.

Fig. 11.



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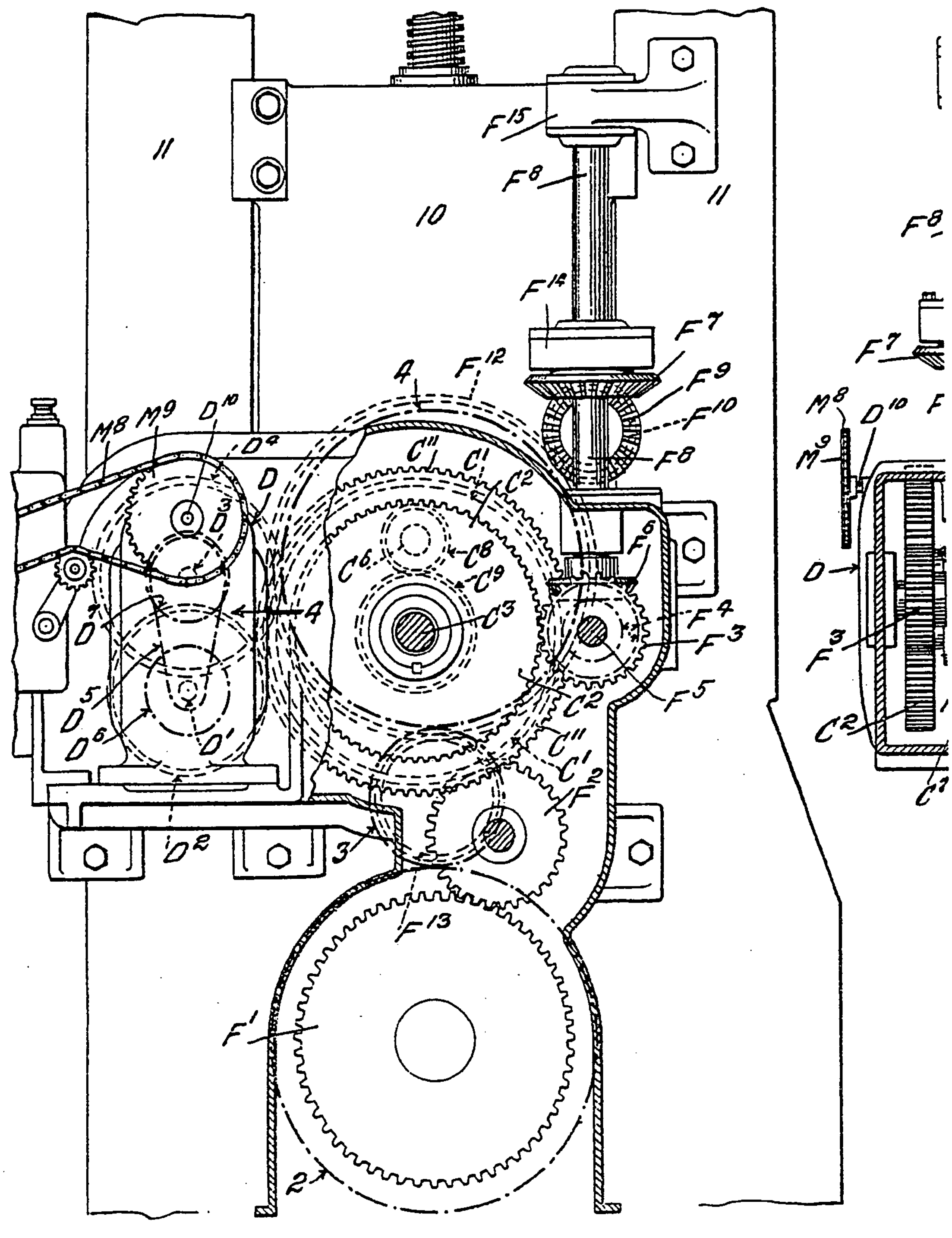

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Fig. 9.

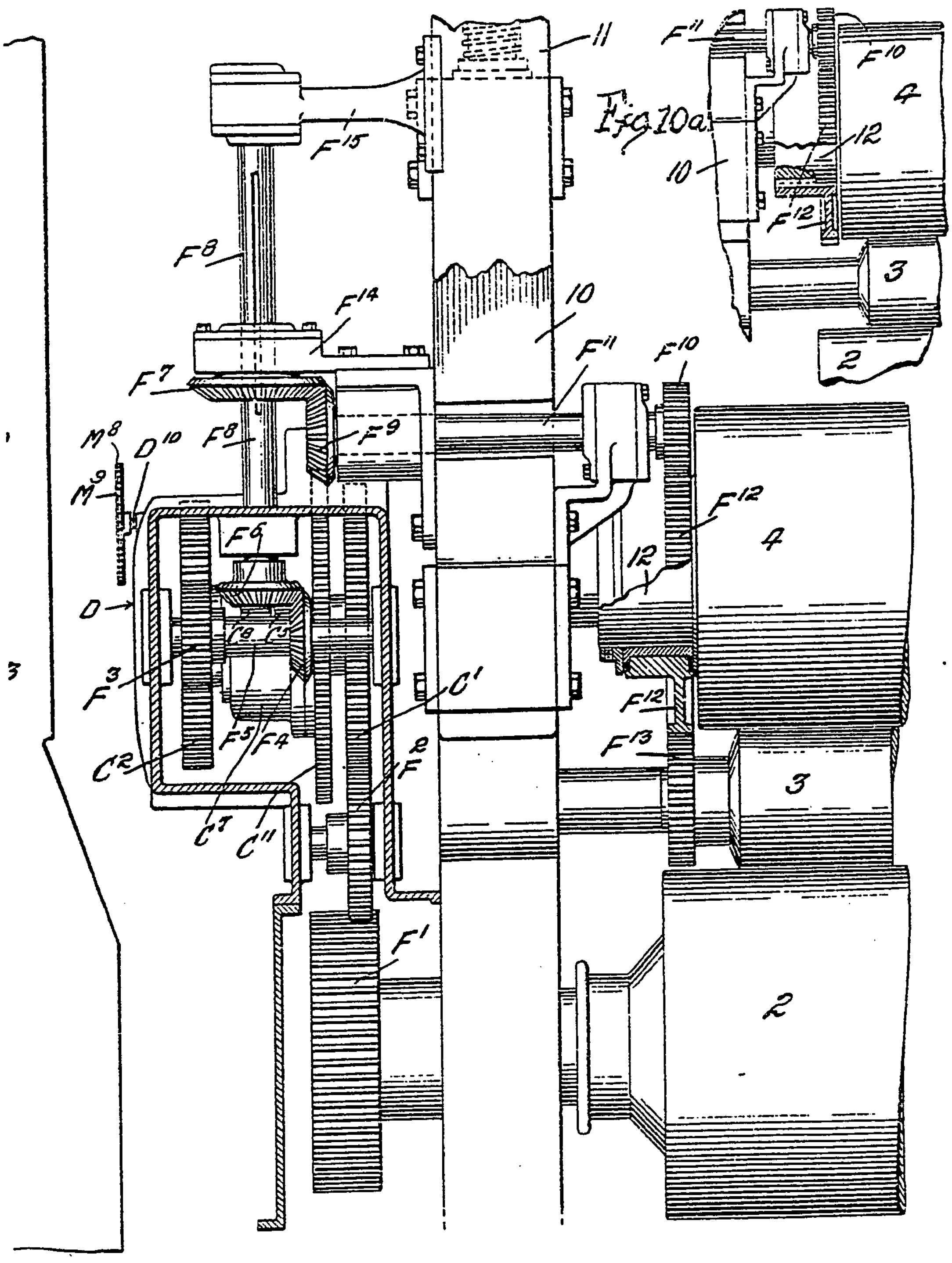
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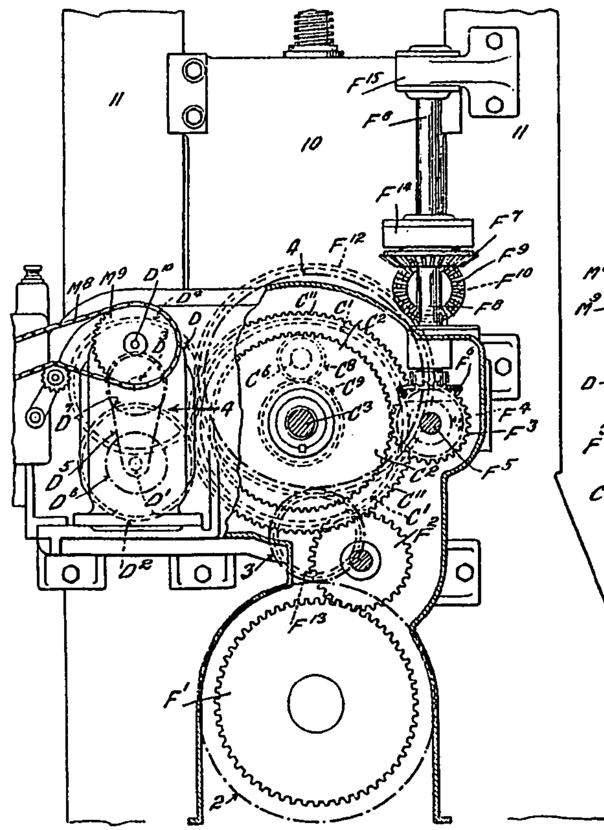
Fig. 10.



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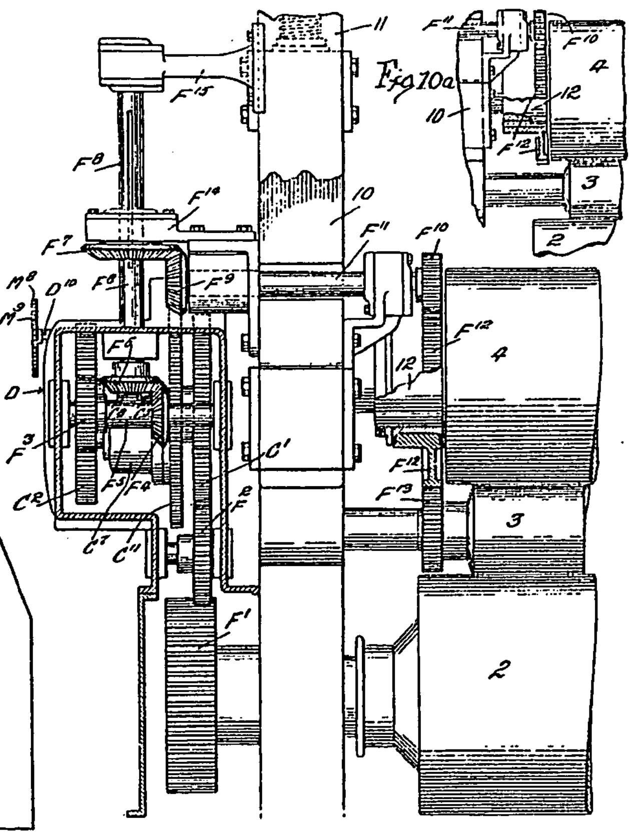

Fig. 10a

Fig. 10.

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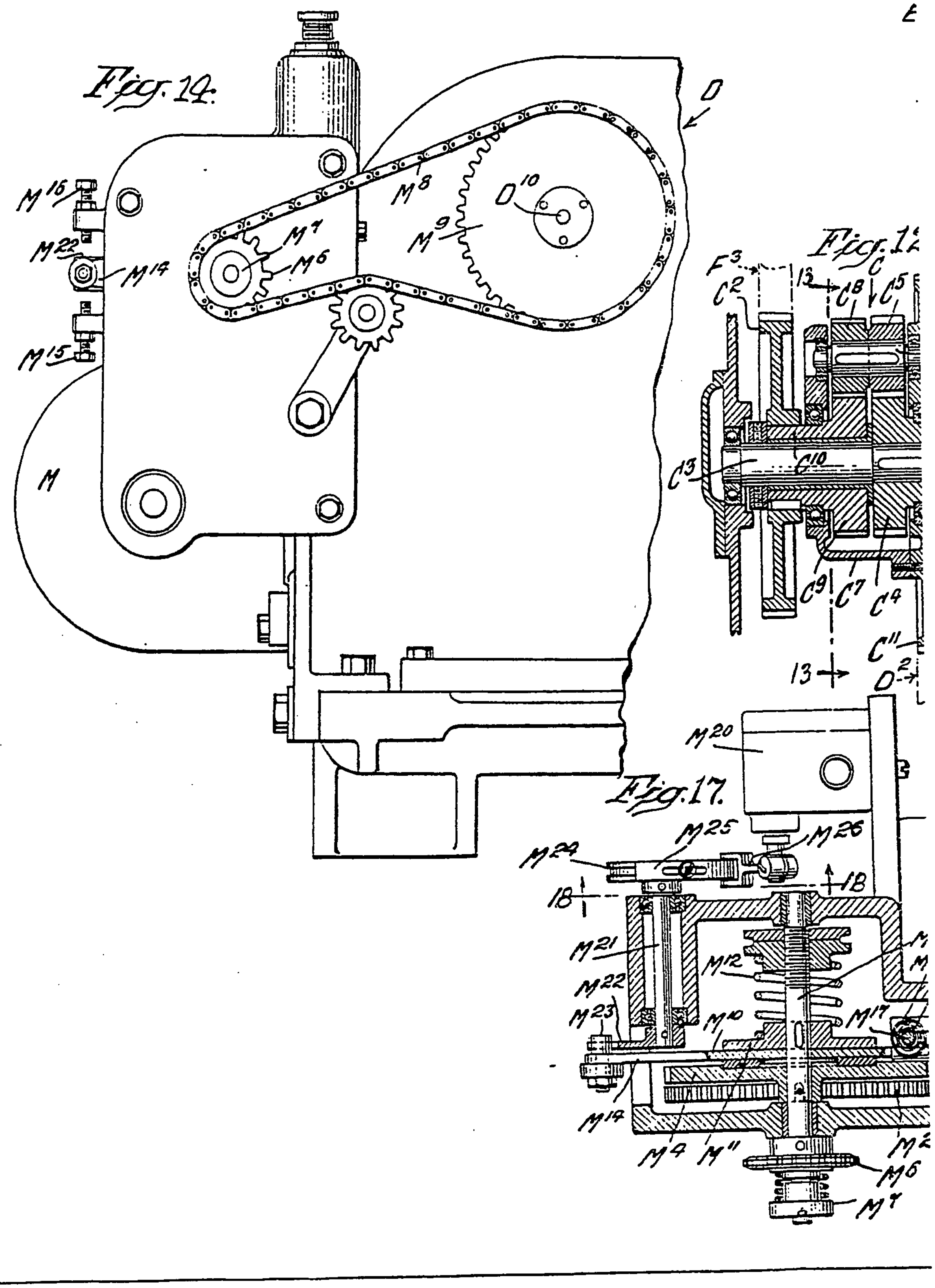
Fig. 14.
D
M^{16}
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M^{7}
M^{6}
M^{9}
D^{10}
M
Fig. 12
F^{3}
C^{2}
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C
C^{8}
C^{5}
C^{13}
C^{10}
C^{9}
C^{7}
C^{4}
C^{11}
D^{2}
Fig. 17.
M^{20}
M^{24}
M^{25}
M^{26}
18
M^{21}
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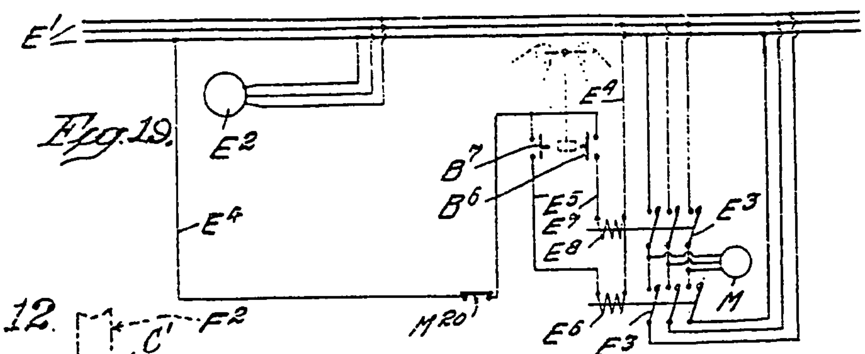
M^{7}

Fig. 19.



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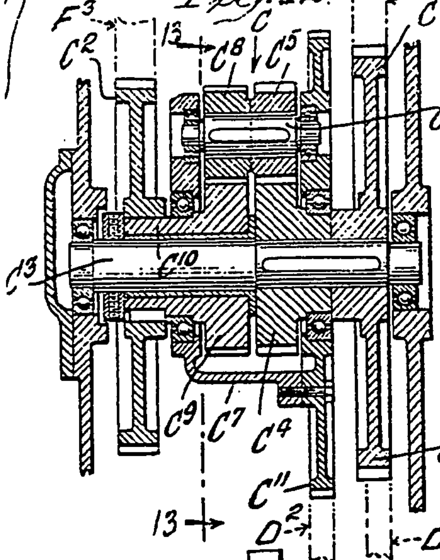


Fig. 16.

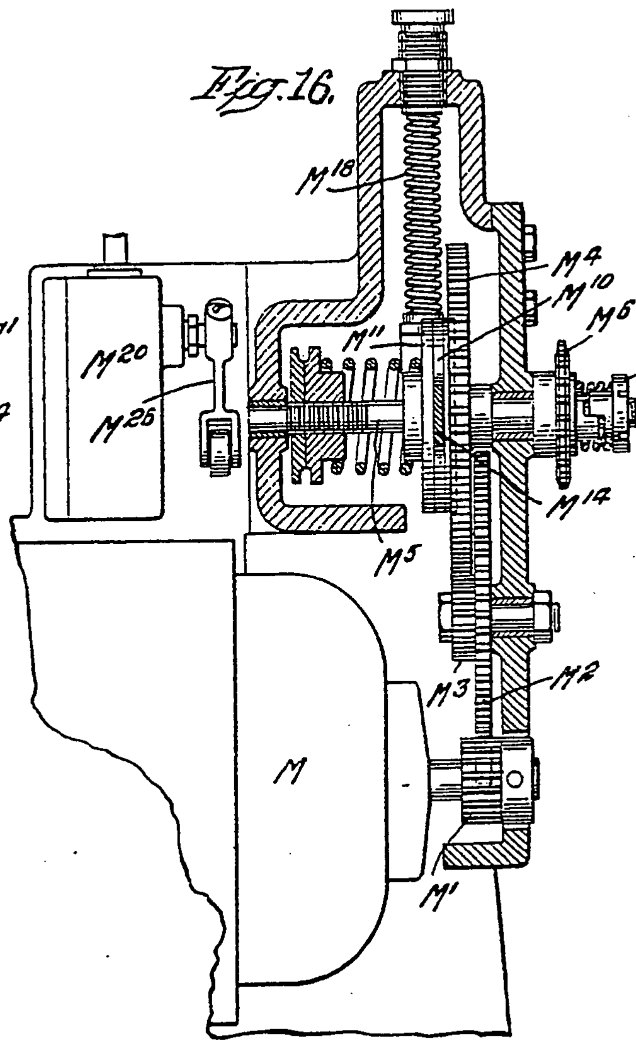
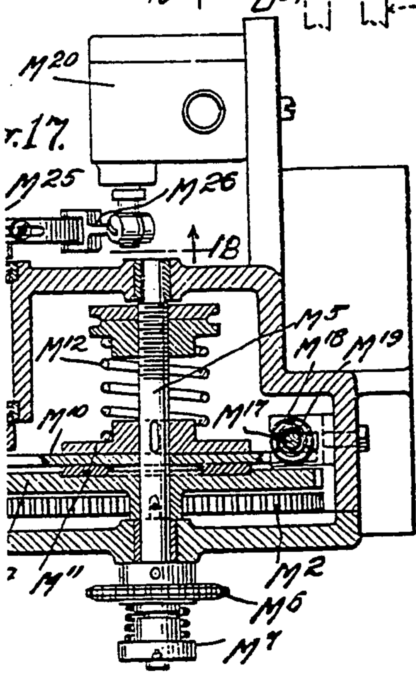


Fig. 17.



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